PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 4 : B65D 6/00, 8/00, 73/00 B65D 30/04, 30/06	A1	(11) International Publication Number: WO 89/ 06624 (43) International Publication Date: 27 July 1989 (27.07.89)

(21) International Application Number: PCT/US89/00167

(22) International Filing Date: 23 January 1989 (23.01.89)

(31) Priority Application Numbers: 146,817 299,076

(32) Priority Dates: 22 January 1988 (22.01.88) 19 January 1989 (19.01.89)

(33) Priority Country: US

(71) Applicant: AMERICAN FUEL CELL AND COATED FABRICS COMPANY [US/US]; 118 East Calhoun, Magnolia, AR 71753 (US).

(72) Inventors: BYERLEY, Donald, L. ; 517 Olive Avenue, Magnolia, AR 71753 (US). SCHOBER, Scott, D. ; 22 Azalea, Magnolia, AR 71753 (US).

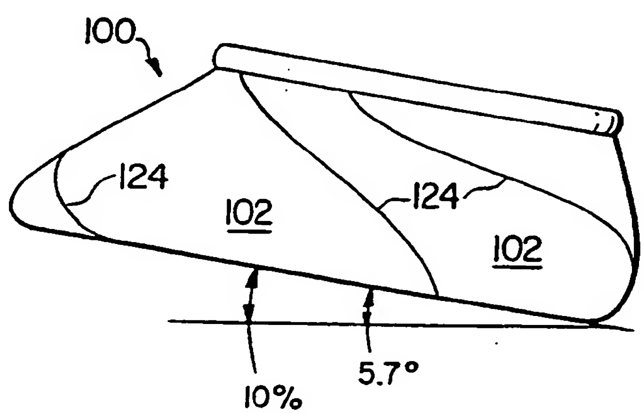
(74) Agents: NIXON, Dale, B. et al.; Richards, Harris, Medlock & Andrews, 4500 Renaissance Tower, 1201 Elm Street, Dallas, TX 75270-2197 (US).

(81) Designated States: AT (European patent), BE (European patent), CH (European patent), DE (European patent), FR (European patent), GB (European patent), IT (European patent), JP, LU (European patent), NL (European patent), SE (European patent).

Published

With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: SLOPE STABLE SINGLE-PLY STORAGE TANK



(57) Abstract

An improved collapsible fluid tank (100) is disclosed which is stable on a slope of 10 % from vertical while using only a single ply fabric (110). The side panels (102) forming the tank are cut from the fabric roll (108) so that the warp yarns (112) of the side panels in the filled tank are at an oblique angle to vertical. The nominal oblique or bias angle of the warp yarns preferably falls in the range between 20° and 70° relative to vertical.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	FR	France	ML	Mali
AU	Australia	GA	Gabon	MR	Mauritania
BB	Barbados	GB	United Kingdom	MW	Malawi
BE	Belgium	HU	Hungary	NL	Netherlands
BG	Bulgaria	IT	Italy	NO	Norway
BJ	Benin	JP	Japan	RO	Romania
BR	Brazil	KP	Democratic People's Republic of Korea	SD	Sudan
CF	Central African Republic			SE	Sweden
CG	Congo	KR	Republic of Korea	SN	Senegal
CH	Switzerland	LI	Liechtenstein	SU	Soviet Union
CM	Cameroon	LK	Sri Lanka	TD	Chad
DE	Germany, Federal Republic of	LU	Luxembourg	TG	Togo
DK	Denmark	MC	Monaco	US	United States of America
FI	Finland	MG	Madagascar		

SLOPE STABLE SINGLE-PLY STORAGE TANK

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part of pending U.S. patent application Serial No. 146,817, filed January 22, 1988.

TECHNICAL FIELD

This invention relates to apparatus for storing fluids, and in particular open topped fabric fluid storage tanks.

BACKGROUND OF THE INVENTION

The military has need of a lightweight portable fluid storage tank. This need can be readily understood when one envisions modern day battlefield conditions. For example, normal civilian sources of potable water in a battle zone may be contaminated, or simply are non-existent. Ideally, the military desires a tank which can be erected at a staging area very quickly, used for such period of time that the staging area is within the battle zone, and then quickly broken down and relocated to a new staging area.

One design which has found some success in this environment is the so-called onion tank. This tank is an open topped collapsible tank formed of fabric, with the perimeter of the tank at the open top forming a floating collar. As the tank is filled with water, or another fluid, the collar floats atop the fluid surface, holding the water within. When the tank is full, the sides bulge under the pressure of the water, forming the tank into a shape having the appearance of an onion.

Because such tanks are intended for use in battlefield conditions, it is considered unlikely that such tanks will always be positioned on horizontal flat surfaces. Therefore, the military has set requirements that such a tank be capable of storing a full liquid load (hold its rated capacity) in a stable manner on a surface sloped at a 10% slope (5.7°). In addition, the military requires that the tank meet a specific height, and that ninetieth percentile personnel must be able to reach into the open top of the tank to take water samples. Tank stability can be increased by decreasing the diameter of the open top relative to the base diameter, but this increases the reach necessary to take samples from the tank beyond acceptable limits. Tank stability can also be increased by decreasing the height

relative to the base diameter, but this also increases the reach necessary to take samples, as well as increasing material usage and must comply with height specifications. The traditional onion tank design used multiple fabric panels or gores sewed together along vertical seams to form the tank. A tank of this design placed on a 10% slope would be so deformed on the downhill side by the weight of the water, or other fluid, that the tank would lose stability. One design has apparently overcome this disadvantage by using two-plies of fabric in each panel. The warp and woof yarns of one layer lie at a 45° angle relative to the other layer, with the layers being carefully fastened together. Such a design is stable at a 10% slope, but requires the extra material necessary to form a two-ply tank, and the effort required to carefully secure the layers together to ensure that the layers do not slide relative to each other and destroy the stability. A need therefore exists for an improved design which is capable of stability on a 10% slope, which does not require the complications of the two-ply design.

SUMMARY OF THE INVENTION

In accordance with one aspect of the present invention, a tank is provided for holding a fluid when positioned on a surface. The tank includes a plurality of panels, with each panel formed of a single ply fabric cut from a fabric roll. The warp yarns of the fabric extend parallel the length of the roll while the woof yarns of the fabric extend parallel the width of the roll. The edges of the panels are secured together to form the tank. The panels are secured together in an orientation so that the yarns of the panels are oriented at an oblique angle to the vertical when the tank is filled to permit the tank to remain stable on a sloped surface.

In accordance with another aspect of the present invention, the panels are cut from the fabric roll so that the nominal bias angle of the warp yarns of each panel extend at an angle from about 20° to 70°, and preferably about 52°, from the vertical in the filled tank.

In accordance with yet another aspect of the present invention, the fabric forming the panels deforms elastically under the forces exerted by the fluid within the tank. The panels are secured together such that the desired oblique angle is achieved when the fabric has been expanded by the fluid in the filled tank.

DETAILED DESCRIPTION

With reference now to the accompanying drawings, wherein like reference numerals designate like or corresponding parts throughout the several views, a conventional two-ply fabric onion tank 10 is illustrated in FIGURES 1 and 2. As can be seen, the tank is formed of a plurality of panels or gores 12 fastened together along vertical seams 14.

As best seen in FIGURE 2, the inner layer 16 and the outer layer 18 are each formed of a fabric having warp yarns 20 and woof yarns 22 criss-crossing at right angles. However, the yarn direction of the inner layer 16 is positioned at a 45° angle from the yarn orientation of the outer layer 18. If the tank 10 were sitting on a perfectly flat horizontal surface, the yarns of the inner layer 16 would also lie at a 45° angle from vertical. The inner and outer layers are secured together by adhesive, seams, or the like, to prevent the layers from sliding relative to each other in a single panel. If constructed properly, a tank of this design is capable of supporting a full liquid load on a 10% slope. However, the complexity of this design is undesirable.

With reference now to FIGURES 3-6, an improved onion tank 100 forming one embodiment of the present invention is illustrated. The tank 100 requires only one layer of fabric material, as will be described in greater detail hereinafter, but is capable of holding a full fluid load on a 10% slope. Thus, the tank 100 has significant advantages over the tank 10 described above.

The tank 100 is formed of side panels 102, a bottom panel 104, and a floating collar 106 secured along the upper edges of the side panels 102 as best seen in FIGURE 3. The collar 106 is of conventional design, and is designed to float atop the particular fluid the tank

is designed to hold. The bottom panel 104 is essentially a simple circular shape. However, the side panels 102 are very specifically formed as discussed hereafter.

With reference to FIGURE 6, the side panels 102 can be seen to be cut from a roll 108 of suitable fabric 110. The fabric will have warp yarns 112 extending side-by-side parallel the length of the roll and woof yarns 114 extending side-by-side across the width of the roll, and perpendicular the warp yarns 112. The fabric 110 will have sufficient density, or be coated with a material making the panels 102 impervious to passage of the fluid being held.

The lower edge 116 of the panel 102 has an arcuate configuration and is designed to be fastened along a portion of the edge of the bottom panel 104. The upper edge 118 is also arcuately shaped and is secured to a portion of the floating collar 106. Side edges 120 and 122 are secured to the side edges of the adjacent side panels 102 to form the seams 124 seen in FIGURES 4 and 5. Ideally, the edges are so oriented relative to the warp and woof yarns so that the warp yarns in each side panel 102 extend at an oblique angle relative to the vertical when the tank 100 is filled with fluid. It has been found that such an oblique orientation provides stability to the tank 100 which allows such a tank to be positioned on a slope as steep as 10% while retaining stability. It is believed that the forces exerted on the downhill side of such a tank 100 by the fluid within the tank are efficiently distributed through the obliquely oriented yarns around the entire tank to resist the tendency toward instability caused by the slope.

In practice, it is impossible to form a side panel 102 from a fabric roll with perpendicular intersecting

warp and woof yarns to have a single uniform oblique angle of the yarns relative to the vertical when formed into a tank. Therefore, it is desirable to cut the side panels to optimize the yarn direction by making the average or mean yarn direction equal to the ideal orientation, with certain yarns as a consequence being at a lesser angle, while other yarns lie at a greater angle. It is believed that a nominal bias angle of between 20° and 70° from vertical in a full tank would be effective. Actual stability tests of nominal bias angles between 25° and 52° have been successful. In the preferred embodiment, a bias angle of 52° is desired. In any event, the width of the fabric roll determines to some degree the bias angle used as the panels must be cut within the dimensions of the roll.

An example of one panel cutting is shown in FIGURE 6. The lines 126 formed in the side panel 102 in FIGURE 6 each indicate the true vertical direction when the panel is part of a filled tank 100. At the lower edge 116, the warp yarns can be seen to be oriented relative to the vertical in a range of angles from 39° to 65°, with the average or mean being about 52°. In the preferred embodiment, the nominal bias angle or average bias angle of the yarns relative to the vertical is about 52°, and the panels are cut from the roll 108 in a manner to best achieve this nominal bias angle throughout the entire side panel.

Typically, the fabric 110 will have some elasticity when exposed to the forces exerted by the fluid within the tank. Such fabric can be expected to stretch about 20% from its non-stressed dimension when holding a full tank of fluid on a 10% slope. The side panels are cut from the roll 108 so that the nominal bias angle is achieved only upon that degree of stretching of the fabric which would be present on the downhill side of he

tank on which the greatest fluid forces are exerted. Thus, the unstressed tank will have a quite non-symmetrical appearance, as seen in FIGURE 3, until the tank is filled with fluid and stretched by the fluid forces to deform the various side panels 102 into the optimum orientation to achieve the nominal bias angle on the downhill portions of the tank.

In one tank constructed in accordance with the teachings of the present invention, a five ounce nylon fabric was used. The end count of warp and woof yarns was 21 yarns per inch with a denier of 840. The fabric was coated with chloroprene rubber, one example of which is sold by DuPont under the trademark "NEOPRENE", to create a waterproof tank. The tank was found not only to be stable at 10% slopes, but even on 11% and 12% slopes.

When a square woven fabric is stressed along a line oblique to the warp and woof yarns, the fabric will elongate substantially more than when the stress is applied in the direction of one of the yarns. This phenomena results by deformation of the nominal square of the weave formed by the intersection of the perpendicular warp and woof yarns into a parallelogram or diamond shape as the stresses are exerted. To minimize the elongation of the side panels 102 incorporated in tank 100, the warp or woof yarns are ideally directed along the force vector created by the fluid in the tank exerted on the down slope walls of the tank at the particular slope angle encountered. For a 10% slope, tank height of 56 inches, tank base diameter of 153 inches, tank opening diameter of 93 inches, and a collar 106 of 4 to 5 inches diameter, having a capacity of 3,000 gallons, an angle of about 52° to vertical is believed optimum. However, as noted previously, it is impossible to achieve precisely this angle consistently

throughout each side panel when the panels are formed of fabric having a square weave. Therefore, as noted previously, the cut of the panels is so to optimize the direction of the yarns to achieve the nominal bias angle of about 52°.

More specifically, the United States of America military standard for military onion tanks, MIL-T-53048A, requires the 3,000 gallon tank to be 57" +- 3" high and have a horizontal radial distance between the tank base diameter and tank opening diameter (the distance a user must reach across from the side of the tank to get to the opening) designed for use by 95% of the users in accordance with the United States of America military standard MIL-STD-1472, Human Engineering Design Criteria for Military Systems, Equipment and Facilities. The relevant factor for this distance is the 5th percentile value of ground troops for "functional reach, extended" from MIL-STD-1472. Section 5.6 of 2 May, 1981, or 33.2 inches. The tank 100 of the present invention designed for 3,000 gallon capacity thus preferably has a height of 57" +- 3" and the horizontal radial distance from the inner side of collar 106 to the tank base diameter is no greater than 33.2 inches (84.2cm), while maintaining the stability requirement on a 10% slope as set out above.

While one embodiment of the present invention has been described in detail herein and shown in the accompanying drawings, it will be evident that various further modifications or substitutions of parts and elements are possible without departing from the scope and spirit of the invention.

CLAIMS

1. A tank for holding a fluid, the tank for positioning on a surface, comprising:

a plurality of panels, each panel formed of a single ply fabric cut from a fabric roll, warp yarns extending parallel the length of the roll and woof yarns extending parallel the width of the roll; and

means for securing the edges of said plurality of panels together to form the tank, the panels oriented in the filled tank with said yarns at an oblique angle to vertical to permit the filled tank to remain stable on a sloped surface.

2. The tank of Claim 1 wherein the nominal bias angle of the warp yarns to vertical is in the range from about 20° to 70° to vertical when the tank is filled.

3. The tank of Claim 1 wherein the nominal bias angle of the yarns to vertical is about 52° when the tank is filled.

4. The tank of Claim 1 wherein the fabric stretches under the influence of the pressure of the fluid within the tank to achieve the oblique orientation of said yarns when the tank is full.

5. The tank of Claim 1 wherein the fabric is a neoprene coated nylon fabric having an end count of 21/ inch for both for warp and woof yarns and a denier of about 840.

6. The tank of Claim 1 wherein the tank will remain stable on a surface sloped to about 10% from horizontal.

7. The tank of Claim 1 wherein the oblique angle is selected to generally lie parallel the force vector exerted by the fluid being held on the down slope side of the tank.

8. A tank for holding a fluid, the tank for positioning on a surface, comprising:

a plurality of side panels, each side panel formed of a single ply fabric cut from a fabric roll, the fabric roll having a square weave with warp yarns extending parallel the length of the roll and woof yarns extending perpendicular the length of the roll;

means for securing the edges of said plurality of side panels together to form the side wall of the tank, the side panels oriented in the filled tank with said warp yarns oriented at an oblique angle to vertical to allow the filled tank to remain stable on a surface sloped up to about 10% from vertical.

9. The tank of Claim 8 wherein the nominal oblique angle of the warp yarns in each side panel is within the range of 20° to 70° from vertical.

10. The tank of Claim 8 wherein the fabric stretches under the influence of the fluid pressure within the tank, the side panels shaped so that the desired oblique angle is achieved when the tank is full.

11. The tank of Claim 8 wherein the nominal oblique angle of the warp yarn in each side panel is about 52° from vertical.

12. The tank of Claim 8 wherein the oblique angle generally corresponds to the force vector of the fluid pressure exerted on the down slope side of the tank.

13. A tank for holding a fluid, the tank for positioning on a surface, comprising:

a plurality of panels, each panel formed of a single ply fabric cut from a fabric roll, warp yarns extending parallel the length of the roll and woof yarns extending parallel the width of the roll; and

means for securing the edges of said plurality of panels together to form the tank, the tank having a height, a tank opening of first diameter and a tank base of second diameter, the height being in the range of 54" to 60" and the radial difference between the second and first diameters not exceeding 33.2", the panels oriented in the filled tank with said yarns at an oblique angle to vertical to permit the filled tank to remain stable on a sloped surface.

14. The tank of Claim 13 wherein the nominal bias angle of the warp yarns to vertical is in the range from about 20° to 70° to vertical when the tank is filled.

15. The tank of Claim 13 wherein the nominal bias angle of the yarns to vertical is about 52° when the tank is filled.

16. The tank of Claim 13 wherein the fabric stretches under the influence of the pressure of the fluid within the tank to achieve the oblique orientation of said yarns when the tank is full.

17. The tank of Claim 13 wherein the fabric is a neoprene coated nylon fabric having an end count of 21/ inch for both for warp and woof yarns and a denier of about 840.

18. The tank of Claim 13 wherein the tank will remain stable on a surface sloped to about 10% from horizontal.

19. The tank of Claim 13 wherein the oblique angle is selected to generally lie parallel the force vector exerted by the fluid being held on the down slope side of the tank.

20. A tank for holding a fluid, the tank for positioning on a surface, comprising:

a plurality of side panels, each side panel formed of a single ply fabric cut from a fabric roll, the fabric roll having a square weave with warp yarns extending parallel the length of the roll and woof yarns extending perpendicular the length of the roll;

means for securing the edges of said plurality of side panels together to form the side wall of the tank, the tank having a height, a tank opening of first diameter and a tank base of second diameter, the height being in the range of 54" to 60" and the horizontal radial difference between the second and first diameters not exceeding about 33.2", the side panels oriented in the filled tank with said warp yarns oriented at an oblique angle to vertical to allow the filled tank to remain stable on a surface sloped up to about 10% from vertical.

21. The tank of Claim 20 wherein the nominal oblique angle of the warp yarns in each side panel is within the range of 20° to 70° from vertical.

22. The tank of Claim 20 wherein the fabric stretches under the influence of the fluid pressure within the tank, the side panels shaped so that the desired oblique angle is achieved when the tank is full.

23. The tank of Claim 20 wherein the nominal oblique angle of the warp yarn in each side panel is about 52° from vertical.

24. The tank of Claim 20 wherein the oblique angle generally corresponds to the force vector of the fluid pressure exerted on the down slope side of the tank.

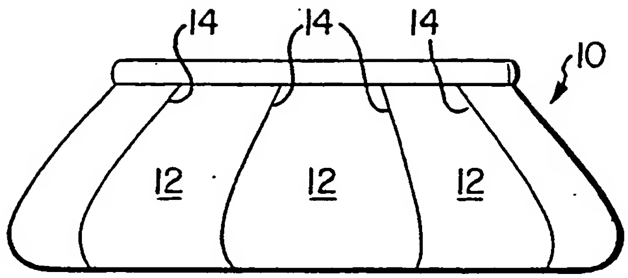


FIG. 1
(PRIOR ART)

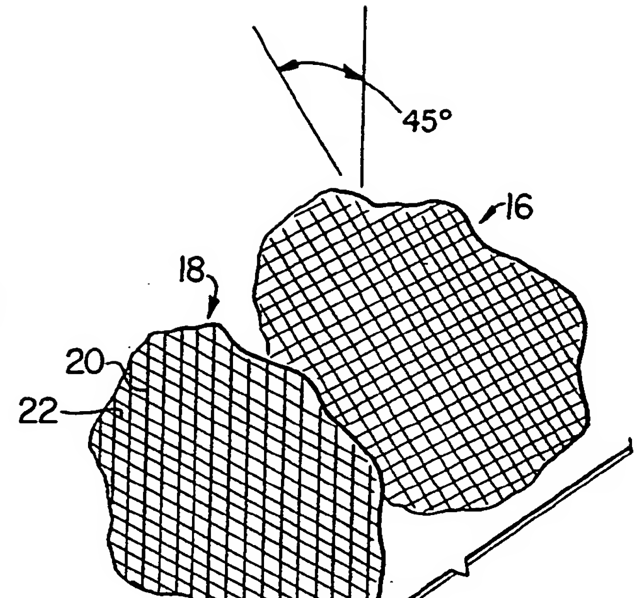


FIG. 2
(PRIOR ART)

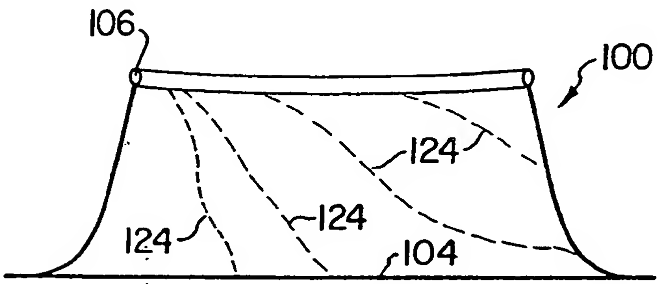


FIG. 3

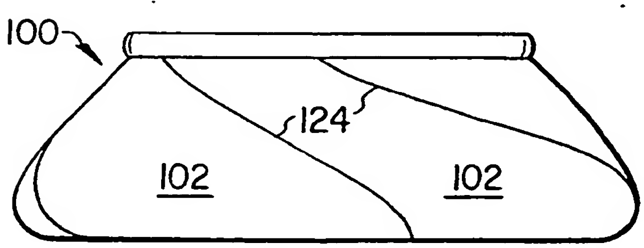


FIG. 4

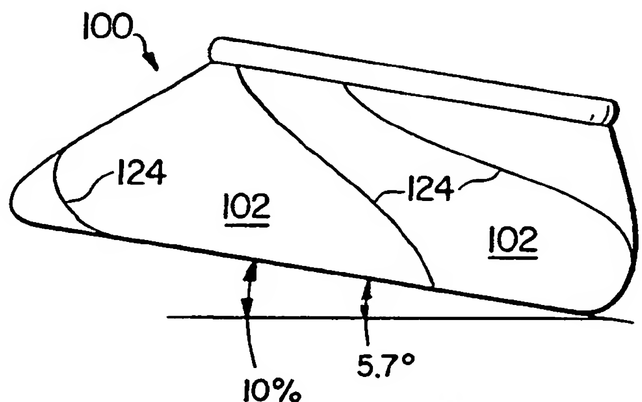


FIG. 5

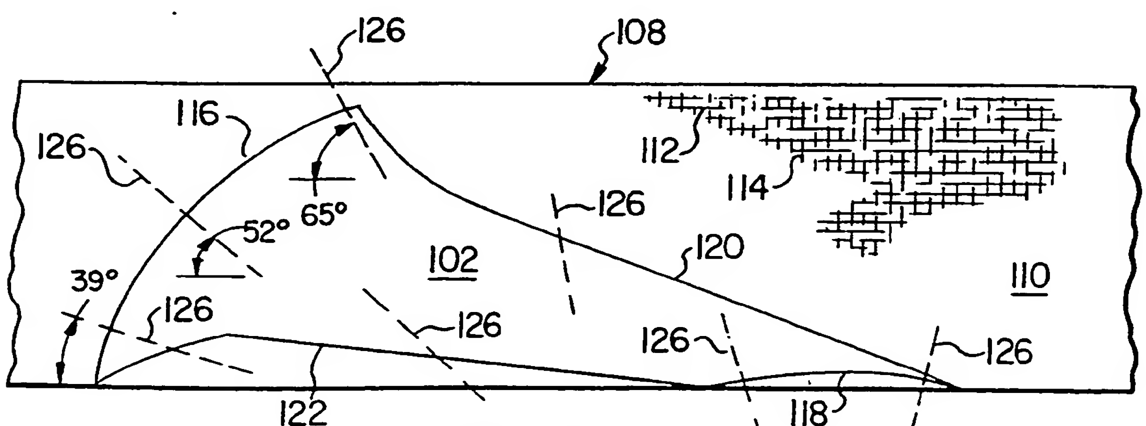


FIG. 6

SUBSTITUTE

INTERNATIONAL SEARCH REPORT

International Application No. PCT/US89/00167

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC(4) B65D 6/00,8/00,73/00,30/04,30/06

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
US	220/5A,1B; 150/127,129,130; 206/469; 383/117,119

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
Y	US, A 2,730,150 (Wunderwald et al), 10 January 1956 (entire document)	1-24
Y	US, A 4,124,049 (Yamaguchi), 07 Nov. 1978 (entire document)	1-24
A	US, A 4,383,564 (Hoie) 17 May 1983	
A	US, A 2,851,075 (Palfey), 09 Sept. 1958	

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
10 April 1989	15 MAY 1989
International Searching Authority	**Signature of Authorized Officer**
ISA/US	Joseph M. Moy